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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

DETAILED ACTION

Response to Arguments

1. Applicant's arguments with respect to claims 1-16 have been considered but are moot in view of the new ground(s) of rejection. Furthermore, upon consideration of the newly added claims, Wrigley and Lathrop in addition to Lee et al. discloses the newly added features of claims 17-39 for the reasons below.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

3. Claim 17-29 and 32-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wrigley (US 5,933,146) in view of Lathrop (US 6,597,359 B1).

4. Regarding claim 17, Wrigley discloses a method for rendering three-dimensional scenes on a display of a computing device, the method comprising: rendering the three dimensional scenes, by the computing device, by means of ray-tracing; (Figure 1 and column 4, lines 47-58)

establishing, by the computing device, a ray-tracing acceleration structure having a plurality of objects; (Figure 6 and column 6, lines 65-67)

traversing, by the computing device, a ray through the acceleration structure until

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an object of intersection is identified; (Column 6, lines 35-64)

storing, by the computing device, the object in a list; (Figure 6, internal tree representation)

Wrigley does not clearly disclose preventing, by the computing device, the object from being intersected more than once by the ray.

Lathrop discloses techniques for reducing the number of ray to object intersection checks depending on the number of objects (Abstract and column 2, lines 31-62).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley's division of objects into envelopes, by minimizing ray to object intersection checks as disclosed by Lathrop because computational performance is increased by not being required to perform unnecessary checks.

5. Regarding claim 18, Wrigley discloses determining, by the computing device, if an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a node of the acceleration structure, the decision being based at least in part on comparisons of the vertices of the triangle with the vertices of the node; and if the affirmative decision is not possible, deciding, by the computing device, by making a conservative decision as to whether the triangle overlaps the node (Column 18, line 64 – column 19, line 40).

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6. Regarding claim 19, Wrigley discloses computing, by the computing device, a three dimensional ray space occupied by a ray according to the ray's increasing distance from a virtual source; (Column 9, lines 9-12)

traversing, by the computing device, the ray space; (Column 9, lines 12-14)

and processing, by the computing device, selected objects identified within the ray space (Column 9, lines 14-28).

7. Regarding claim 20, Wrigley discloses the ray space is a selected one of a cone or a pyramid, and the method further comprises processing, by the computing device, objects within the ray space, and ordering the objects according to the objects' virtual distances from the virtual source of the ray (Figure 2).

8. Regarding claim 21, Wrigley discloses the ray-tracing acceleration structure further comprises at least one acceleration structure node, with each node being associated with a region of node space, and the method further comprises (Figure 6): storing, by the computing device, simplified geometry data associated with each acceleration structure node; (Figure 6 and column 6, lines 35-47, envelopes)

and computing, by the computing device, a ray-object intersection, using the simplified geometry data to compute the ray-object intersection when the ray space overlaps a majority of the node space (Column 6, lines 48-64).

9. Regarding claim 22, Lathrop discloses subdividing, by the computing device, the plurality of objects into an n-level hierarchy of objects and sub-objects; (Figure 5 and column 7, lines 39-62)

classifying, by the computing device, the objects as primitive or non-primitive; and, after traversing a ray through the acceleration structure until an intersected object is identified, if the identified object is not a primitive object, storing, by the computing device, affine transformation data which transforms the object and ray into a coordinate system locally associated with the identified object, and traversing the local coordinate system and storing affine transformation data, recursively, until the ray intersects with a primitive object; (Column 10, lines 49-67)

and if the identified object is a primitive object, storing by the computing device, transformation data which transforms the primitive object and ray into a normalized object space locally associated with the identified object, intersecting the transformed ray with the transformed identified object, and storing, by the computing device, ray-object intersection data (Column 11, lines 1-19).

10. Regarding claim 23, Lathrop discloses subdividing, by the computing device, the plurality of objects into an n-level hierarchy of objects and sub-objects; (Figure 5 and column 7, lines 39-62)

recursively instantiating, by the computing device, a plurality of sub-objects, the sub-objects having a similar geometry; (Column 8, lines 32-49)

and building, by the computing device, a next level object by, at least in part, using the plurality of instantiated sub-objects with similar geometry (Column 8, line 64 – column 9, line 8).

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11. Regarding claim 24, Wrigley discloses An apparatus for rendering three-dimensional scenes, the apparatus comprising: a processor; (Figure 9, element 74)

a tangible computer-accessible storage medium operatively coupled to the processor; (Figure 9, element 70)

a ray-tracing acceleration structure stored in the storage medium, the acceleration structure having object data for a plurality of objects; (Figure 6 and column 6, lines 65-67)

Wrigley does not clearly disclose a ray-casting module operatively configured to traverse rays through the acceleration structure and return ray-object intersection data, the ray-casting module comprising a decision unit operatively configured to prevent objects from being intersected by a ray more than once.

Lathrop discloses techniques for reducing the number of ray to object intersection checks depending on the number of objects (Abstract and column 2, lines 31-62).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley's division of objects into envelopes, by minimizing ray to object intersection checks as disclosed by Lathrop because computational performance is increased by not being required to perform unnecessary checks.

12. Regarding claim 25, Wrigley discloses determining if an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a node of the acceleration structure, the decision being based at least in part on

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comparisons of the vertices of the triangle with the vertices of the node; and if the affirmative decision is possible, store the affirmative decision as part of establishing the acceleration structure (Column 18, line 64 – column 19, line 32).

13. Regarding claim 26, Wrigley discloses if the affirmative decision is not possible, a conservative decision as to whether the triangle overlaps the node and store the conservative decision as part of establishing the acceleration structure (Column 19, lines 33-40).

14. Regarding claim 27, Wrigley discloses the ray-casting module further comprises a traversal unit, the traversal unit operatively configured to: compute a three dimensional ray space occupied by a ray according to the ray's increasing distance from a virtual source; (Column 9, lines 9-12)

and traverse the ray space through the acceleration structure from the virtual source of the ray through an increasing virtual distance from the virtual source of the ray. (Column 9, lines 12-14)

15. Regarding claim 28, Wrigley discloses the ray space traversed is a selected one of a cone or a pyramid (Figure 2).

16. Regarding claim 29, at least one acceleration structure node, each node being associated with a region of node space; (Figure 6)

and wherein the ray casting module is further configured to store simplified geometry data associated with each acceleration structure node; (Figure 6 and column 6, lines 35-47, envelopes)

and, when the ray space overlaps a majority of the node space, compute ray-object intersection using the simplified geometry data (Column 6, lines 48-64).

17. Regarding claim 32, Wrigley discloses an article of manufacture comprising a tangible computer-accessible storage medium (Figure 9, element 70) for digitally storing a plurality of programming instructions designed to program an apparatus to render three-dimensional scenes by means of ray-tracing, wherein the programming instructions, if executed by the apparatus, enable the apparatus to: establish ray tracing acceleration structures having a plurality of objects (Figure 6 and column 6, lines 35-67).

Wrigley does not clearly disclose preventing objects that have already been intersected by a ray during ray tracing from being intersected again by the ray.

Lathrop discloses techniques for reducing the number of ray to object intersection checks depending on the number of objects (Abstract and column 2, lines 31-62).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley's division of objects into envelopes, by minimizing ray to object intersection checks as disclosed by Lathrop because computational performance is increased by not being required to perform unnecessary checks.

18. Regarding claim 33, Wrigley discloses determining if an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a

node of the acceleration structure, the decision being based at least in part on comparisons of the vertices of the triangle with the vertices of the node; and if the affirmative decision is not possible, decide by making a conservative decision as to whether the triangle overlaps the node (Column 18, line 64 – column 19, line 40).

19. Regarding claim 34, Wrigley discloses computing a three dimensional ray space occupied by a ray according to the ray's increasing distance from a virtual source; (Column 9, lines 9-12)

traverse the ray space through the acceleration structure; (Column 9, lines 12-14)

and process selected objects identified within the ray space (Column 9, lines 14-28).

20. Regarding claim 35, Wrigley discloses the ray space traversed by the ray is a selected one of a cone or a pyramid, and the programming instructions, if executed, further enable the apparatus to process the objects within the ray space, and order the objects according to the objects' virtual distances from the virtual source of the ray (Figure 2).

21. Regarding claim 36, Wrigley discloses storing simplified geometry data associated with each acceleration structure node; (Figure 6 and column 6, lines 35-47, envelopes)

and when the ray space overlaps a majority of the node space, compute ray-object intersection, using the simplified geometry data (Column 6, lines 48-64).

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22. Regarding claim 37, Lathrop discloses subdividing the plurality of objects into an n-level hierarchy of objects and sub- objects; (Figure 5 and column 7, lines 39-62)

classifying the objects as primitive or non-primitive; traversing a ray through the acceleration structure until an intersected object is identified, if the identified object is not a primitive object, store affine transformation data which transforms the object and ray into a coordinate system locally associated with the identified object, and traverse the transformed ray through the local coordinate system and store affine transformation data, recursively, until the ray intersects with a primitive object; (Column 10, lines 49-67)

and if the identified object is a primitive object, store transformation data which transforms the primitive object and ray into a normalized object space locally associated with the identified object, intersect the transformed ray with the transformed identified object, and store ray-object intersection data (Column 11, lines 1-19).

23. Regarding claim 38, Lathrop discloses subdividing the plurality of objects into an n-level hierarchy of objects and sub- objects; (Figure 5 and column 7, lines 39-62)

recursively instantiating a plurality of sub-objects, the sub-objects having a similar geometry; (Column 8, lines 32-49)

and building a next level object by, at least in part, using the plurality of instantiated sub-objects with similar geometry (Column 8, line 64 – column 9, line 8).

24. Claims 30, 31 and 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wrigley (US 5,933,146) in view of Lathrop (US 6,597,359 B1) and further in Lee et al. (US 2004/0233222).

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25. Regarding claim 30, Wrigley in view of Lathrop discloses all limitations as discussed in claim 24.

Lathrop further discloses a transformation unit(Column 11, lines 1-19); and a ray casting unit (Figure 3, element 15).

Wrigley in view of Lathrop does not clearly disclose a matrix unit; wherein the matrix unit is operatively configured to send affine transformation matrices of object data to the transformation unit, each affine transformation matrix being a selected one of an object-space transformation matrix and a normalized space transformation matrix, and the transformation unit is further operatively configured to receive a ray from the ray casting unit and transform the ray into the object's affine transformation matrix's coordinate system.

Lee discloses performing affine transformations using an affine transformation matrix (Paragraphs 0046 and 0047).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wrigley in view of Lathrop to performing a transformation using an affine matrix as disclosed by Lee because a simpler coordinate system can be obtained while preserving collinearity after the transformation.

26. Regarding claim 31, Lathrop discloses an acceleration structure computation unit operatively configured to subdivide the plurality of objects into an n-level hierarchy of objects and sub-objects and store data classifying the objects as primitive or non-primitive; (Figure 5 and column 7, lines 39-62)

a traversal unit operatively configured to traverse a ray through the acceleration

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structure until a potential ray-object intersection is identified; (Column 12, lines 60 – column 13, line 3)

and an intersection computation unit; (Column 13, lines 3-10)

wherein, the transformation unit is operatively configured to send the object's affine transformation matrix data and the transformed ray data to the transversal unit for recursive processing until the ray intersects with a primitive object, if the object identified by the traversal unit is not a primitive object; (Column 10, lines 49-67)

and wherein, the transformation unit is operatively configured to send the object's affine transformation matrix data and the transformed ray data to the intersection computation unit, if the object identified by the traversal unit is a primitive object (Column 11, lines 1-19).

27. Regarding claim 39, Wrigley discloses a ray casting processor for rendering dynamic three-dimensional scenes, the processor comprising: a traversal unit, the traversal unit being coupled to a plurality of node caches for storing acceleration structure node data, the node data structured to improve accessibility according to ray coherence, the node caches arranged in an n-level hierarchy; (Figure 6 and column 6, lines 35-67)

a list unit, the list unit being coupled to a plurality of list caches for storing lists of object addresses for objects that have already been intersected by a ray, the list caches arranged in an n-level hierarchy (Figure 6, internal tree representation).

Wrigley does not clearly disclose the list unit having a decision unit, the decision unit configured to prevent objects or triangles from being intersected by the ray more

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than once.

Lathrop discloses techniques for reducing the number of ray to object intersection checks depending on the number of objects (Abstract and column 2, lines 31-62).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley's division of objects into envelopes, by minimizing ray to object intersection checks as disclosed by Lathrop because computational performance is increased by not being required to perform unnecessary checks.

Wrigley in view of Lathrop does not clearly disclose a matrix loading unit, the matrix loading unit being coupled to a plurality of matrix caches for storing affine transformations in the form of matrices, the matrix caches arranged in an n-level hierarchy.

Lee discloses performing affine transformations using an affine transformation matrix (Paragraphs 0046 and 0047).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wrigley in view of Lathrop to performing a transformation using an affine matrix as disclosed by Lee because a simpler coordinate system can be obtained while preserving collinearity after the transformation.

Conclusion

28. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to PHI HOANG whose telephone number is 571-270-3417. The examiner can normally be reached on Mon-Fri, 8:30am-5:00pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Xiao Wu can be reached on 571-272-7761. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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August 27, 2009

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